

Machine Learning 1

Lecture 9.1 - Unsupervised Learning
Latent Variable Models

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(Bishop 9.0)



Unsupervised vs. Supervised learning

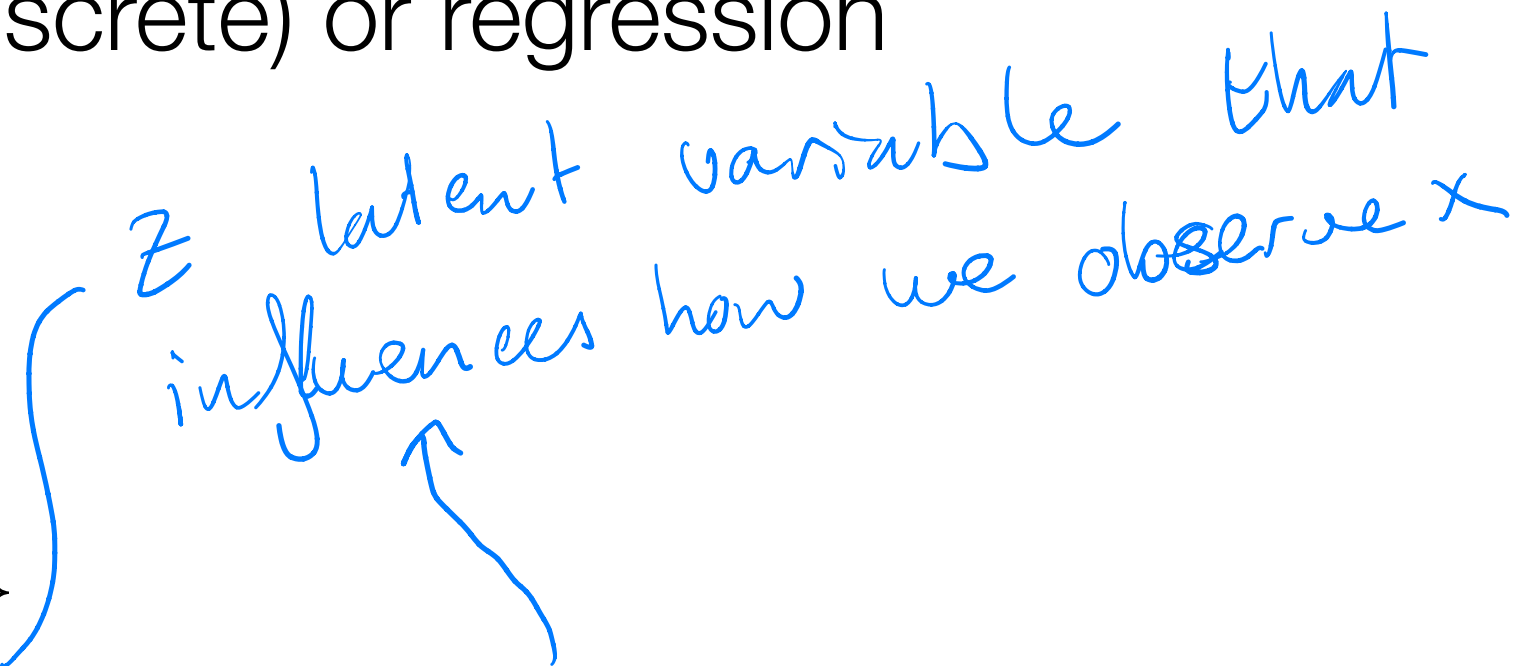
- ▶ Supervised

- ▶ Data $D = \{\mathbf{X}, \mathbf{T}\}$
- ▶ Goals $f(\mathbf{x}) \approx t, p(\mathbf{t}|\mathbf{x})$
- ▶ Classification (discrete) or regression (continuous)

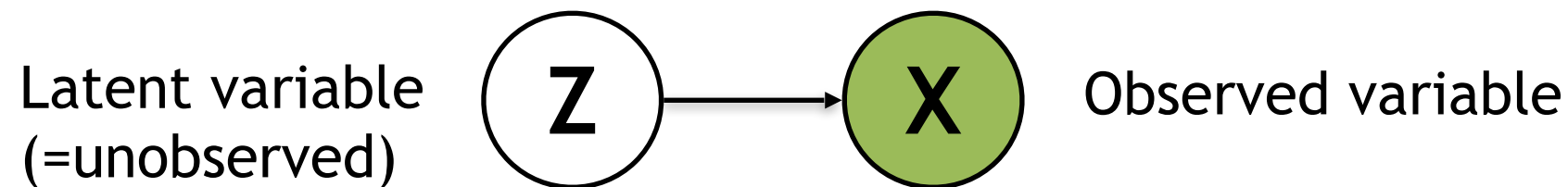
- ▶ Unsupervised

- ▶ Data $D = \{\mathbf{X}\}$
- ▶ Goals $p(\mathbf{x}), p(\mathbf{z}|\mathbf{x})$ or $p(\mathbf{x}|\mathbf{z})$
- ▶ Density estimation, **clustering** (discrete) or **dimensionality reduction** (continuous)

\mathbf{z} latent variable that influences how we observe \mathbf{x}



Latent variable models



- ▶ Model complex distributions with more tractable representation by z
- ▶ continuous:

$$p(\mathbf{x}) = \int p(\mathbf{x}, \mathbf{z}) d\mathbf{z} = \int p(\mathbf{x}|\mathbf{z})p(\mathbf{z})d\mathbf{z}$$

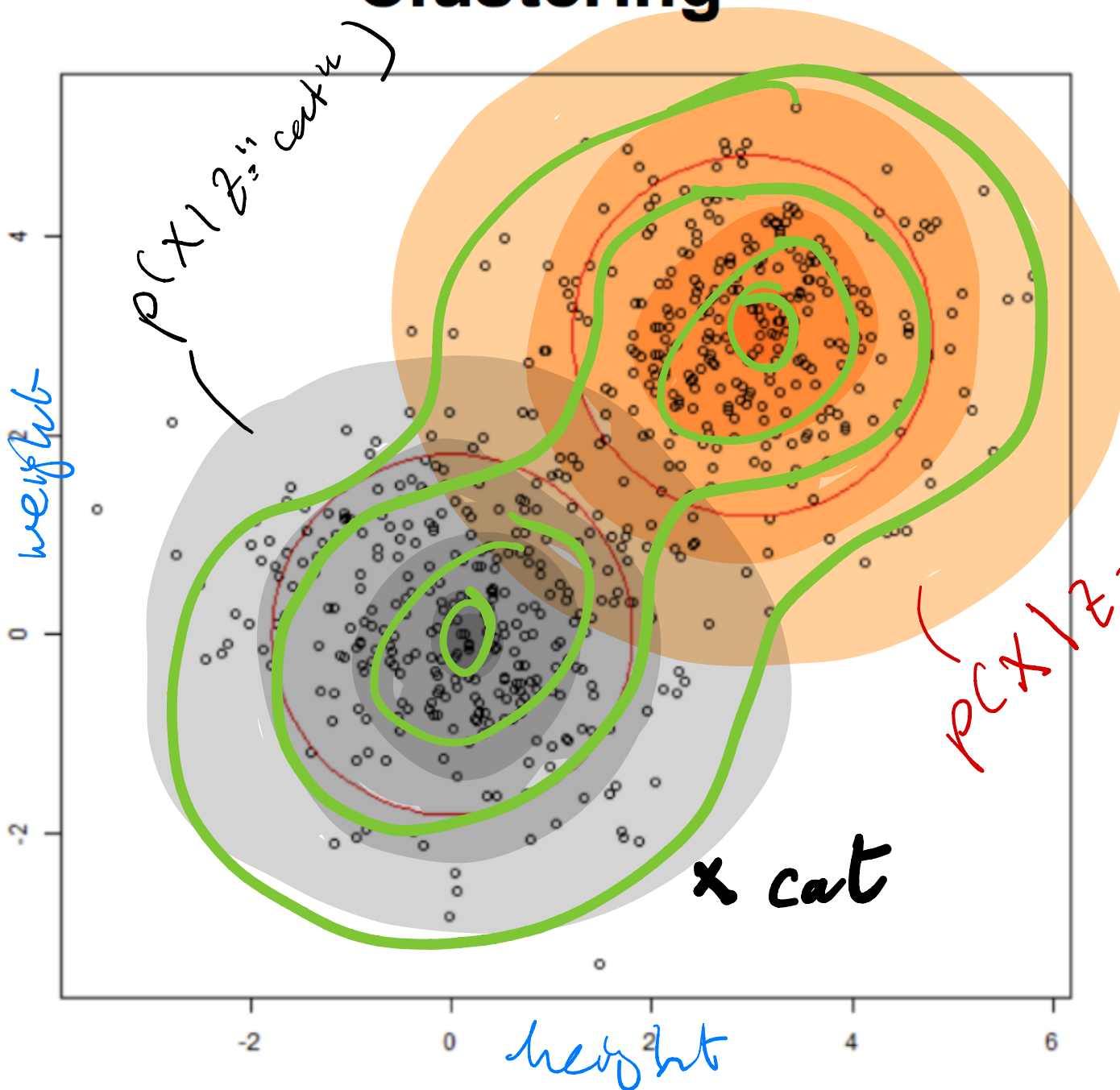
- ▶ discrete:

$$p(\mathbf{x}) = \sum_{\mathbf{z}} p(\mathbf{x}, \mathbf{z}) = \sum_{\mathbf{z}} p(\mathbf{x}|\mathbf{z})p(\mathbf{z})$$

Examples

$$p(\underline{x}) = \sum_z p(\underline{x}, z) = \sum_z p(\underline{x} | z) p(z)$$

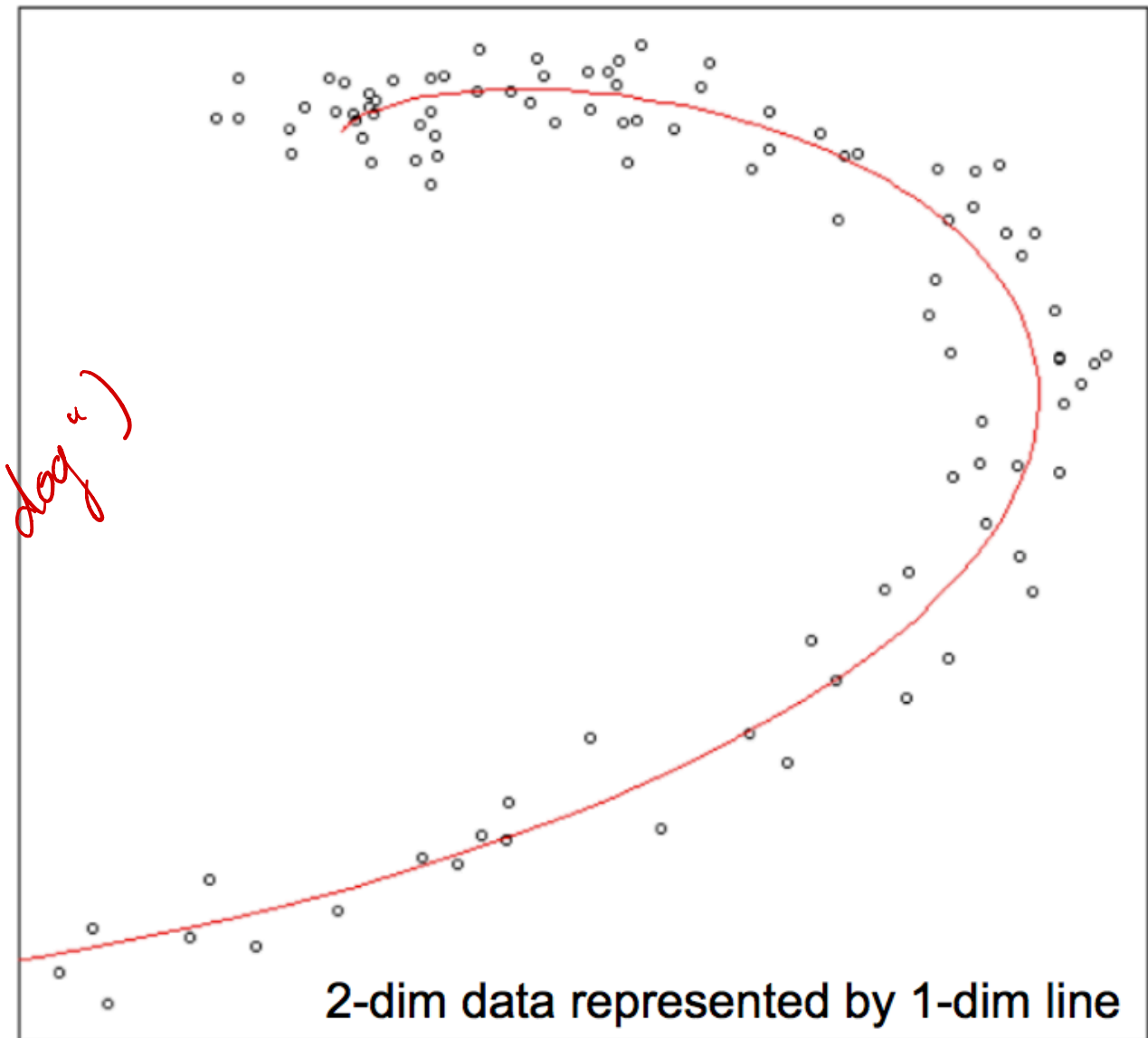
Clustering



Discrete latent variables

animal type

Dimensionality reduction



Continuous latent variables